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THE EFFECT OF FOREST FIRE ON BREEDING BIRDS IN PONDEROSA PINE FORESTS

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INTRODUCTION

In areas where lightning set fires, both common and frequent, fire is obviously a part of the natural environment. The unique adaptations of certain plants and animals to conditions during and after burning (Sweeney, 1956; Mayfield, 1960) and the dependence of certain environments on fire (Habeck and Mutch, 1973) indicate that fire is an integral physical variable. The effects of fire on breeding bird populations are not well known; especially the effects on non-game avian species. The current study was designed to observe the influence of natural, uncontrolled forest fire on the non-game avifauna in the fire prone ponderosa pine forests of northern Arizona.

Although breeding bird populations have been studied in a variety of habitats that have suffered disturbance by man's activities or were succeeding through seral stages (Odum, 1950; Johnson & Odum, 1956; Martin, 1960; Hagar, 1960; Kerr, 1968; Carothers et al., 1974), few detailed studies concerning the relationship between birds and habitat destruction by fire (natural or man-made) have been undertaken. Studies that have been done in fire prone areas have addressed themselves primarily to game species such as grouse or quail (See Tall Timbers Fire Ecology Proceedings). Fire studies dealing with non-game species, are seldom of a long term, systematic nature (Marshall, 1957, cf. Bendell, 1974).

Most of the systematic studies on non-game breeding bird populations in burned areas that have been completed, show either an increase or little change in both richness and abundance of birds. These studies were conducted, for the most part, 5 to 10 years after the burning took place. Thus the forest had some time to recover from the disturbance in the sense that an understory had time to form.

Kilgore (1971), working with prescribed burning in Sequoia National Park, California, noted some changes in the composition of the bird population after treatment of the forest by thinning and burning of the slash. Most notable were the increased numbers of ground feeders and flycatchers. This was attributed to the opening up of the canopy layer. The changes, however, were less correlated to the actual effects of burning than to a change in habitat structure affected by removal of trees of a certain DBH. Buck and Lynch (1970) observed bird population trends in burned and unburned areas on Donner Summit in the Sierra Nevada Mountains of California 5 to 6 years after fire. They found a slight increase both in species diversity and in standing crop biomass on the burned sites. This illustrates that the forest avifauna was not depauperated by the fire. Lowe et al (in press) found an increase in total bird numbers in burned areas in northern Arizona. Their findings on different aged burns showed that total numbers increased 1 to 2 years after the burn, then decreased to below an unburned area in a 20 year old burn. There was a marked increase in ground feeding birds. In their study, breeding birds were not assessed. Total number of birds using the study areas were counted during the early part of the season when many migrants were moving through the area. Roppe (1974) found an increase in flycatchers and ground feeders in burned lodgepole pine forests in Colorado. There was a corresponding decrease in foliage gleaning birds because of the reduction of the shrub layer with the burn. In contrast, Ruffner et al (unpubl.) found that the number of breeding birds in ponderosa pine forests of northern Arizona was dramatically reduced after treatment of the forest by controlled fires.

These contradictory results gave impetus to the current study in the ponderosa pine forest surrounding Flagstaff, Arizona. In spite of the results obtained by Lowe et al (in press), breeding birds of the ponderosa pine forest fauna seems to respond differently to burning than in other fire prone forests. The objective of

the current study was to investigate how the ponderosa pine forest breeding birds respond to the effects of forest destruction by fire and to determine what environmental factors allow this response of occur.

The ponderosa pine forest is considered to be a pyroclimatic community (Cooper, 1960). That is, the predominant vegetation and the habitat structure is controlled almost exclusively by the effects of fire.

Situated in an area of BW climatic type (Strahler, 1969), characterized by summer rains, the ponderosa pine belt is subjected to frequent and severe lightning storms following a period of drought. These lightning storms emit many strikes that ignite trees and set many fires in the forests.

European man began to settle Arizona and exploit its forest resources around 1874 and thereafter forestry management practices were put into effect (Cooper, 1960). Chief among these was fire suppression. A few dedicated men noted the adverse effects of the newly implemented management practices in Arizona (notably Cooper, 1960 and 1964; Pearson, et al., 1972). The most obvious long term results were a reduction in forage herbs and grasses and an increase in thick groves of spindly pines crowded into dog-hair or jack-pine thickets. The latter phenomenon tended to act as tinder for the frequent fires that swept through the forests. As the thickets grew taller, they would allow flames to reach the canopies of the older trees, causing the blazes to "crown out". This lead to wholesale destruction of the forest and a reduction in usable timber.

In recent years, forest fires in the ponderosa pine belt have become more frequent and more dangerous (Bennett, pers. comm.). According to Forest Service personnel (Don Witt, pers. comm.), if a fire is not stopped before it reaches 10 acres in size, so much heat will be generated that it can easily spread to thousands of acres. Control and containment of the blaze becomes a near impossibility when this happens.

Recently the value of fire has become more apparent to forest managers. In areas where controlled burns have been completed, natural fires have been much less destructive to the timber trees (Skarra, 1969; Kallander, 1969). In many cases, the opening of the environment seems to stimulate a greater number of animals, notably large mammals, to use the areas (Lowe et al, in press; Bendell, 1974; Nelson, 1974). This latter fact is considered to be a great recreational attribute, increasing the use of the forests by hunters.

In the spring of 1975 four study areas were chosen and surveyed. One area was unburned and served as a control and three were burned from 3 to 9 years in the past. All burn sites were severely damaged. Although not all the burn sites were effected by fires stemming from natural causes, no fire was a controlled burn. The areas were censused for breeding birds from May through late July in 1975 and through early August in 1976.

During the 1975 season the burn sites, while supporting fewer total birds, did support a relatively greater number of foraging birds than the control. The abundance and richness of these ground feeders appeared to increase as the season progressed. Not only were migrant flocks seen feeding in the area but also small flocks of birds (such as Yellow-rumped Warblers and Pine Siskins) that nested only in the unburned forests. Robins, Western Bluebirds and Gray-headed Juncos in small flocks or family groups fed in the burned areas after the young had fledged. In the unburned area, these birds were not observed in small flocks or family groups, but tended to remain in pairs after the young had left the nest.

Some resource(s) in the burned areas must have made the burned areas more attractive than the unburned forest during the latter half of the breeding season. This resource allowed families to stay together longer and a larger number of birds to utilize the area. The lack of this resource in the unburned forest forced family groups to split up and the young to scatter shortly after fledging.

In 1976 the breeding bird censuses were divided into four collection periods of three weeks each. Number of birds feeding on the ground were carefully recorded in order to monitor their increases over the season.

The ponderosa pine forest surrounding Flagstaff, Coconino County, Arizona, is part of a vast forest system covering about 3,000,000 acres (1,200,000 hectares) in the southwestern United States (Cooper, 1960). It has been designated the Transition or Yellow Pine Zone by C. Hart Merriam in his life zone system concept (Merriam, 1890). Extending elevationally from about 6100 ft (1876 m.) to about 8500 ft (2615 m.), the forest supports an almost pure stand of ponderosa pine.

METHODS AND MATERIALS

BIRD SAMPLING

Birds were censused using the spot map method (Kendeigh, 1944; Williams, 1936). A series of lines was surveyed on each site, each line being 30 m apart. Lines running in one direction were numbered: lines running perpendicularly were lettered. Thus a point, being the intersection of two lines, could be identified by a number and a letter. A strip of red or orange plastic flagging tape was secured on or near each point for ease in field location. Grid maps were drawn for each site and enough copies made so that each census was recorded on a separate map. When a bird was seen or heard during a census period, its location was noted and marked on the map. A census map should thus be a record of all the bird species seen during that census period. The census maps were then broken down into composite species maps which were a record of all sitings of a particular bird species during the entire season. All birds seen and heard were recorded as well as their sex (if determinable), activity (singing, feeding, perching) and location within the three vegetational stratal categories (canopy, sapling or ground). A fourth locational category, that of bark and trunk use, was added. A concentrated effort was made to find active nests, especially for those very mobile species

whose numbers were hard to determine such as Violet-green Swallows and Pygmy Nuthatches.

Censuses were conducted during the early morning hours, starting about 1/2 hour after sunrise and lasting for 1 1/2 to 3 hours. The duration of a census was determined by the activity of the birds: the more activity that was exhibited, the longer the census period. Activity, such as song advertisement and foraging, seemed to be influenced by temperature and cloud cover. Cold temperatures tended to depress activity as did clear skies.

Territories of breeding pairs were determined by isolating clusters of sitings of presumably the same individual. A cluster of three was considered the minimum number of sitings required to denote a territorial holding although, in some cases, the structure of the vegetation had also to be taken into account. The presence of an active nest was a sure indication of a breeding pair, regardless of the total number of sitings in the vicinity. Total number of breeding pairs of each species was then counted and a ratio constructed to calculate pairs per 40 hectares. This was done for each site for both years.

Violet-green Swallows and Pygmy Nuthatches, because of their mobility and vociferousness, proved very difficult to count. Therefore, in 1975, breeding pairs were determined for both species by calculating and summing the average number of sitings per census. In 1976, breeding pairs were determined by locating and counting the total number of active nests.

In 1976 censuses were divided into 4 collection periods of 3 weeks each. Number of ground nesting and feeding birds was determined by dividing the total number of birds seen on the ground by the total census hours during that given collection period.

VEGETATION SAMPLING

Vegetation was measured using the 0.1 acre method of James and Shugert (1970).

Points were chosen within each site from the array of grid points used for bird censusing. Around each point, a circle 0.1 acre in diameter was marked off by siting with a premeasured reach stick to a siting stick placed over the point. All trees within the circle were counted. A tree was considered to be any living plant with a diameter of or greater than 7.5 cm. (3 in.) DBH. The species was recorded and the tree categorized as to diameter size class. Size classes ranged from a through k in 7.5 cm intervals, the last including all trees greater than 75.0 cm (30 in.) DBH.

James and Shugert (1970) suggest field calculation of trees per acre to determine the number of points needed to obtain an accurate estimate of absolute density. Twelve points were measured on the Pearson Natural Area and 11 points were completed on the other three sites.

These and all other calculations were converted into hectares to be consistant with metric measurements. One hectare equals about 2.5 acres and 40 hectares about 100 acres. Thus, comparisons to previous work is possible and convenient.

In the Pearson Natural Area, which served as the control, only live trees were recorded.

The burned areas were analyzed using the same 0.1 acre method. In this case, however, burned standing trunks and live trees were treated as separate entities, as few live trees remained. This gave some idea as to the severity of the burn, a hotter fire killing a greater number of large trees than a cooler one. Cut stumps were measured as to diameter at ground level and also recorded separately. Summing the absolute densities of live trees, dead trunks and cut stumps gave an approximation of absolute density of trees per hectare prior to the burn.

From these data, relative density, relative diversity, relative dominance and importance values were calculated using the formulas in Cox (1969). In a monoculture such as the ponderosa pine forest of northern Arizona, these calculations are

somewhat redundant, the expected and calculated importance values equalling or nearing 300%. However, in the burned areas, such calculations describe the live and dead vegetation quantitatively and serve as a basis for comparison between sites.

Quantitative measurements of the burn sites proves very useful by increasing the predictive powers of future researchers and managers. An old, severe burn may be similar in physiognomy to a younger, less severe burn and the responses of the avifauna in the two areas similar. If this is so, vegetative measurements will give the manager a preliminary idea of what to expect in terms of faunistic dynamics.

Number of saplings and burnt stems less than 7.5 cm. DBH were determined by counting the absolute number of stems encountered by the body and outstretched arms while traversing the 0.1 acre circle twice in perpendicular transects (James and Shugert, 1970). This was then converted into saplings per hectare, using the following formula:

$$\frac{\dfrac{\text{total saplings in all transects}}{} \times 1000}{\text{number of transects}} \times 2.5$$

Percent stratal vegetation cover was measured using an ocular tube (Winkworth and Goodall, 1962) and a foliage-height-diversity pole (Carothers et al, 1974). Vegetation was divided into 3 layers after McArthur (1964) but with some modifications. Ground vegetation consisted of all living plants up to .5 m.; sampling layer was between 15 m. and 6.0 m. in height with the exception of tall grasses which were always included in the ground layer (Karr, 1968); canopy layer included all living vegetation about 6 m.

The ocular tube is a cardboard tube having two cross hairs perpendicular to each other at each end. Lining up the intersections of the cross hairs at each siting insured consistancy in measurement. The tool was used to determine coverage

at the ground and canopy levels. Any green vegetation sited behind the intersections of the crosshairs was considered a plus. On the ground layer bare ground, fules (any debris greater than 7.5 cm. in diameter found lying on the ground), and living vegetation was recorded. In the canopy stratum, only presence or absence of cover was noted.

The foliage-height-diversity pole was 5.5 m. in length. Held upright with the base braced against the knee, yielded measurements of vegetation between .5 m. and 6.0 m. in height. Any living vegetation touching the pole along any of its length was considered a plus. This tool was used exclusively in the sapling stratum and, again, only presence or absence of living vegetation was recorded.

A total of 32 measurements in each stratal category was made at each 0.1 acre point. This, multiplied by the number of points analyzed, yielded total number of recordings. The total number was used to calculate the percent cover within each stratum. On the ground level, percent coverage by fuels, bare ground, and living vegetation was calculated as all make up separate components in the habitat. Each area was observed to be used in foraging in a different manner and, in many cases, different species used an area preferentially for nesting. Furthermore, quantifying the amount of fuels on the ground gives another indication of the influence of fire in the environment. Many trees fall or are blown over in the years succeeding fire. These fuels, steadily but naturally accumulating, provide material for another fire at a future date. The quantified fuel factor can be helpful not only in predicting the severity of a future fire but can also be useful in analyzing the successional stages apparent in a pyroclimax type habitat.

In 1975 a complete vegetational analysis was done on each site in late July.

In 1976 ground cover only was measured. This was done four times during the spring and summer seasons. Ten points on each site were selected from the array of grid points. Different points were chosen at each measurement period to increase randomness.

Plants were collected from each site as they came into bloom over the two year period. If the same species was found on all or several of the sites, only one was collected and a note of its presence on the other sites made. These specimens were preserved by pressing and drying and were returned to the lab for identification and compilation of plant species lists. The specimens are in the Deaver Herbarium, University of Northern Arizona, Flagstaff, Arizona.

ANALYTICAL PROCEDURES

Total standing crop biomass, consuming biomass and existance energy requirements per 40 hectares were calculated for each site each year.

Standing crop biomass is simply the weight, in grams, of a species. Summed, this figure gives the total grams of bird found on an area (Salt, 1957).

Consuming biomass is calculated as (Kerr, 1968):

gms. weight .733

This gives an approximation of the grams weight food consumed by the bird community present. The above calculations are better used in community comparisons than total numbers, richness or abundance because community dynamics are based on energetics.

Existance energy is calculated from the formula in Weiner and Glowacinski (1975):

$$EMR = 1.572W^{0.6210} + 0.06514W^{0.3625} (30 - t)$$

where W is weight in grams and t is temperature in degrees centegrade. Not only is bird weight taken into account but also the average ambient temperature of the area. The latter is important because an animal will consume or require more energy in cooler temperatures. This calculation gives an estimate of the amount of energy in kilocalories per bird day required to support the number of birds in the community.

J' is an index of diversity calculated from the Shannon-Weaver (1949) formula:

$$H' = \Sigma(-p\log p)$$

and modified by Pileou (1966) to:

$$J' = H'/H_{max}$$

H' includes both richness, or number of species in a community, and abundance, or number of individuals representing a species. The Shannon-Werner calculation yields a number representing the relationship between the two or the evenness of the community. A perfectly even population is one in which each species is represented by an equal number of individuals. The index is meaningless by itself, however. Pileou's ratio relates the observed evenness to the expected or maximum possible evenness. This index ranges from 0 to 1, the former being a completely unbalanced community and the latter with each species represented equally.

Morisita's (1959) index of community similarity was used to determine how alike each community was to each other. This is calculated by:

$$\frac{2 \sum_{i=1}^{s} x_i y_i}{(\lambda_x + \lambda_y) XY}$$

This calculation indicates the probability that two individuals taken from different populations will be of the same species. (Horn, 1969).

Average number of ground feeders per hour per collection period was calculated by dividing the total birds observed feeding on the ground by the total number of census hours per collection period.

A regression line was fitted to the points using the formulae in Li (1969).

Spearman Rank Correlation Coefficient was used to decide what factors in the environment were influencing the increase in ground feeding birds. Probabilities were calculated using (Siegel, 1956):

$$r_s = \frac{6\ (\sum d^2)}{n^3 - n}$$

where d is the difference between two ranks and n is the number of sample collections.

Percent change in breeding bird densities between the two years was calculated from Wiens (1975). This was done for each site. The resultant number indicates the magnitude of population fluctuations.

STUDY AREAS

In the winter and spring of 1975, four study plots were located in the ponderosa pine forest near Flagstaff, Coconino County, Arizona. One site, the Pearson Natural Area, was unburned and served as the control; the other three had been burned by wildfire at some time in the past. The three burn sites were all within patches of forest that had suffered crown fires so that most, if not all, of the trees on the areas were killed.

1. Pearson Natural Area: This site is located 8 miles west of Flagstaff on highway 180 (figure 1). It is situated at 2341 m. elevation (7200 ft.). A 40 hectare area had been set aside for scientific study under the jurisdiction of the Rocky Mountain Forest and Range Experimental Station. Designated a natural area, it has been protected from fire for up to 70 years and no cutting or clearing has been done on the site since 1902. For this reason it was chosen as the control site.

The study site is long and relatively narrow. It is bordered on one side by highway 180. The site covers a 12.0 hectares (30 acres) area. Two graded forest service roads bisect the area. One, at the north end, was blocked off in 1976. The other, FSR 222, cuts through the southern end of the study site and is extensively used.

Since 1975, extensive thinning has been done around the area for construction of a fire break along the highway. Also in 1975, a small area in the middle portion of the site and along 180, was cleared as a vehicle turn-out and a sign erected identifying the area as natural. Use of the turn-out did cause some disturbances to the birds as most activity ceased when the area was occupied by motorists.

The Pearson Natural Area is a good representation of the pine forests of northern Arizona. Somewhat overstocked (588 trees per hectare, Table I), it is

choked with dense jack-pine thickets. The area supports 20,105 saplings per hectare (Table 1) which tend to provide ready tinder for fire. These small trees were probably from the 1919 seed crop and, for the most part, do not exceed 10 m. height. Both sapling and canopy cover, which reduce light reaching the lower strata, are extensive, the latter reaching 50% (Table 2). The ground, covered with a thick layer of pine needles, supports very little forage (27.8%, Table 2). In 1976, this percent cover was little augmented in spite of the warm, wet spring season (Table 3).

Ground fuels were not extensive (4.7%, Table II) although natural accumulation was occurring (Table 3). In the winter of 1976 two large dead trees were blown down by strong winds. These accumulations of dry wood also provide fuel for future fires.

The dominant plant was Ponderosa Pine (Pinus ponderosa Laws. All plant names follow McDougal, 1973) which made up the canopy and the sapling strata. Other shrubby plants were counted as part of the herbaceous layer due to their low height. Fendler's Buckbrush (Ceanothus fendleri Gray) was the dominant perennial. Grasses and forbs dominated the herbaceous stratum. Plant species found on the Pearson Natural Area are listed in Table 4.

2. Wild Bill 1973 Study Area: This burn site was located within the Wild Bill burn near the White Horse Hills north of the San Francisco Peaks and about 45 miles north of Flagstaff. The study plot was located on FSR 416 and was near the northeast end of the 3400 hectare burn (figure 1). Situated at an altitude of 2400 m. (7300 ft.), the study site incorporates an area of 8.6 hectares (21.5 acres). The Pinon-Juniper community (Upper Sonoran Life Zone (Mirriam, 1890)) begins to dominate 1.5 miles east of the site.

Wild Bill 1973 was severely burned by a lightning caused fire in October, 1973. Although many stems and large trunks remain standing (Table 1), the saplings

and trees are dead, reducing any foliage cover in the upper strata to zero (Table 2). Some salvage cutting of the largest trees was done after the burn. With 610 trees per hectare prior to the burn (Table 1), this area was as well forested as the Pearson Natural Area. Aggregations of small burned stems attest to the presence of substantial jack-pine thickets which were cleared by the fire. Clearing and burning of slash and ground fuels was completed in August, 1975 which reduced the total percent fuels (Table 2). Although the clearing casued some disturbance to the area, the burning was confined to two large slash piles at one end of the site. Ground fuels did accumulate in localized areas as dead stems rotted or were blown over (Table 3).

It is significant to note the increase in herbaceous cover on Wild Bill, 1973 over that found in the Pearson Natural Area (Tables 2 and 3). Although the burned area had been broadcast seeded with Smooth Brome (Bromus inermis Leyss.), Timothy (Phleum pratense L.), and Sweet Clover (Melilotus officinalis (L.) Lam.) (Pearson 1970; Rominger, pers. comm), by 1975-76 the dominant plant cover was Russian Thistle (Salsola kali var. tenuifolia Tausch.) and a native Lupine, Lupinus Kingii Wets. In 1975 the ground was barren until mid-June. After that the percent ground cover steadily increased until it reached 46.5% in late July (Table 2). This was predominately Lupine. Many plants germinated early in the spring of 1976. By mid-May, Wild Bill, 1973 was supporting 40.312% ground cover (Table 3), again, predominately Lupine. June proved to be somewhat dry and though percent coverage continued to increase through August, about half the lupine died and were supplanted by Russian Thistle. Plant species collected during the two year study period from Wild Bill, 1973 are presented in Table 5.

Many tiny seedlings, few over 3 cm. high, were observed near Wild Bill, 1973 in 1976. These were found under younger trees that had escaped devestation but where the fire had burned off some, if not all, of the original duff layer.

3. Rattle Burn: This site was located in the middle of the Rattlesnake burn which flamed southwest of Flagstaff in May, 1972. The site was located on FSR 231,

30 miles south of old highway 44 (figure 1). The Rocky Mountain Forest and Range Experimental Station, using the area for reforestation experiments, had a 10 hectare plot fenced off from cattle. Eight and six tenths hectares of that plot were incorporated into the current study site.

The site was somewhat lower in elevation than the others, being 2092 m. (6800 ft.), and was from 1 to 3 miles from the Moguillon Rim. It supported New Mexican Locust (Robinia neomexicana Gray) and Gambel's Oak (Quercus gambellii Nutt.) in addition to Ponderosa Pine. Though the area was probably influenced by dry updrafts from Oak Creek Canyon, it seemed to receive more precipitation than the other sites.

In 1975 it was thought that the locust and oak that had been burned were dead, as neither leafed out in the spring or sent up root shoots. In 1976, however, the locust, located in a small clump at the west edge of the site began growing extensively from terminal buds. The oak on the site sent up root shoots that grew to almost a meter in height by August. This is interesting, as it represents asexual regeneration four years after damage by fire.

The Rattle Burn site shows the same general vegetational trends as found on Wild Bill, 1973, though the area was not quite so heavily forested prior to the burn (500 trees per hectare, Table I). Aggregations of small stems indicated that there were a few jack-pine thickets on this particular portion of the burn.

There was a greater amount of ground fuels on this site than on either of the previously described areas (Table 2 and 3). Since the area had been isolated for scientific study, slash and ground fuels had not been cleaned out, though slash was gathered into piles. These ground fuels can provide protection and nesting sites for ground foraging and nesting birds, but they also provide tinder for future fires. Ground fuels accumulate naturally (Pearson et al., 1972) in an area where decomposition is slow relative to tree and branch fall. The Rattle Burn site reflects this rapid and natural accumulation.

As in Wild Bill 1973, the Rattle Burn site supported a high percentage of ground cover by August, 1975 and 1976 (Tables 2 and 3). Although there were a large number of Mullen (Verbascum thapsis L.) present, the dominant species were Gayophytum and grasses. The growth trends were similar to that on Wild Bill, 1973, that is, the 1976 growing season started much earlier than in 1975 (Table III). A change-over in dominants however, was not apparent.

This area showed a much more diverse flora than found on any other site. This could be a reflection of the proximity of the rim. A list of plant species is found in Table 6.

The Rattle Burn site had been planted to pine seedlings in early summer, 1975 and although many of these died before the summer rains in mid-July, those that did survive, survived very well and grew rapidly during the warm, wet wpring of 1976.

Though the two burn sites described above burned in different years, destruction seemed, superficially, to be the same. Some trees, located in small clumps, were untouched by the fire, yet, for the most part, all trees on the sites were dead. Natural reforestation was not readily apparent on either site. This could be a reflection partly of low seed crops, of inclement weather, of the difficulty experienced by roots of germinating seeds in penetrating a fire baked clay soil (Rietveld, pers. comm.) or of allelopathic actions by native grasses inhibiting the pine seedlings (Rietveld, 1975).

4. Wild Bill, 1967: This wite was located 13 miles northwest of Flagstaff of FS road 164C (figure 1). It burned in May, 1967. The altitude is 2341 m. (7300 ft). The area had been set aside and measurments taken by the Rocky Mountain Forest and Range Experimental Station for 5 years previous to the fire (Pearson et al., 1972). The location of the 8.6 hectare study plot was in an area of unthinned pine forest and the fire caused total destruction. Total basal area of timber (ft^2/acre) was reduced from 135.4 to 4.2 after burning (Ibid). Absolute density of burned stems per hectare was 58 (Table 1). Thirty live trees per hectare existed on the site.

This figure is an overestimation. The live trees present in the sample, except for 7 individuals, were in a shallow draw at the west boundary where, due possibly to increased soil moisture, the fire moved only along the ground.

Wild Bill 1967 is somewhat of an anomily in that the area is practically a meadow. The few stems that remained standing were used, for the most part, as perches only. Some natural reforestation was apparent around one of the live trees in the middle of the site. No reforestation was occurring along the edges adjacent to lightly burned forest. The reason for this is unknown.

Ground fuel levels were very high (Tables 2 and 3) and little of the slash had been collected into piles. In this case the downed stems were scattered randomly over the entire surface of the ground. Nesting activity occurred only where an old slash pile remain or where a large trunk fell over exposing a tangle of roots.

It was felt that both Wild Bill 1973 and the Rattle Burn site could become much like Wild Bill 1967 with increased blowdowns as the dead pine trunks rotted in the soil. That blowdowns were continuing to occur in Wild Bill 1967 was evidenced by the fact that about half the stems holding survey flags fell over by the end of the 1975-76 seasons.

Percent ground cover was quite high (Tables 2 and 3). Although a variety of herbaceous plants grew in the area, the cover was predominately made up of grasses. Some shrubby perenials were reinvading, namely Fendler's Buckbrush, but the plants were still quite small in 1976. The area had been reseeded with Orchard grass (<u>Dactylis glomerata</u> L.) and Smooth Brome (<u>Bromus inermis</u> Leyss.) after the fire (Pearson et al., 1972). Growth of these forage plants was optimal two years after burning and thereafter their dominance declined (Ibid). A list of plants collected from Wild Bill 1967 is presented in Table VII.

Some large mammals were observed on all three burn areas but few indications of use were seen on the Pearson Natural Area. Elk were seen on and near Wild Bill 1973 during both years. An inseperable trio -- two horses and a burro -- included this study site in their home range. Traps were set for coyote by the U. S. Fish

and Wildlife Service in 1976. Coyotes were heard frequently in the surrounding hills although none were seen. Deer and Elk were seen extensively on the Rattle Burn site as these animals were able to jump the fence. Bear tracks were found there in 1975. Deer were observed in Wild Bill 1967 during both years and cattle were occasionally found there in 1976. Coyotes were heard on the site at night and many scat were found along the road. No large mammals were seen on the Pearson Natural Area although the sighting of cattle dung attested to their occasional presence.

RESULTS

In 1975 the Pearson Natural Area supported 18 nesting species with 251 pairs per 40 hectares (Table 8). Haldeman et al (1973) found 23 species with 232 pairs per 100 acres in a 1968 census of the same study area. The standing crop biomass and consuming biomass were also higher in the 1968 census (15,993 gms/40 hr to 11,739. gms/40 hr. respectively) than in the 1975 census. The species missing during the 1975 breeding season were the heavier bodied birds (i.e., Brewer's Blackbird, Black-headed Grosbeak and Hermit Thrush). Species with higher densities in 1975 compared to 1968 were the Pygmy Nuthatch and Violet-green Swallow.

In 1976 the Pearson Natural Area supported 23 species of birds with a total of 354 pairs per 40 hectares (Table 9). Although the number of species was the same as in the 1968 census, the Pearson Area gained Western Tanagers (heard in the area but not seen nesting on the site), Brown-headed Cowbirds and Northern Three-toed Woodpeckers not found there in 1968. The species missing were the Brewer's Blackbird, Black-headed Grosbeak and the Goshawk that were there in 1968.

The increase in pairs per 40 hectares over the 1968 census was, again, mostly in the smaller bodied species such as the Pygmy Nuthatch (20-53), Pine Siskin (9-37), Violet-green Swallow (30-50), Mountain Chickadee (20-30), Yellow-rumped Warbler (8-13) and the Western Wood Peewee (4-10). There was also an increase in medium sized birds such as the Western Bluebird (15-30) and the Gray-headed Junco (23-33).

Although the average temperatures between the 1975 and 1976 seasons were similar (Table 10), 1976 proved to be moister and more temperate. The species list in 1976 was augumented by those birds requiring more moisture such as the Hermit Thrush, Western Flycatcher, Pine Siskin and Northern Three-toed Woodpecker. These four species plus the Broad-tailed Hummingbird fit no size categorey, their weights ranging from 4 gms. to 58.5 gms. There was an increase in abundance of all species in 1976 excpet for the Western Tanager, Hairy Woodpecker, Brown Creeper, Solitary

Vireo, and Western Wood Peewee, all of which showed a slight reduction in pairs per 40 hectares. The Brown-headed Cowbird and Grace's Warbler showed no change in numbers.

Standing crop biomass, consuming biomass and existance energies in 1976 showed an increase corresponding to the greater number of birds found that year (Table 9).

J' remain much the same between the two breeding seasons (Table 11). This indicates that the proportionate number of individuals representing each species was close to equal regardless of the change in richness and numbers of pairs per 40 hectares between the two seasons.

In 1975 groups of 6 to 8 male Brown-headed Cowbirds were observed calling from the tops of the tallest snags at the end of the breeding season. Small groups of Gray-headed Juncos were seen feeding in the area and Western Bluebirds flew back and forth across the area, calling loudly. In 1976, again, small groups of Gray-headed Juncos were seen feeding on the ground in the area, but not more than 3 birds in any one place. The Pygmy Nuthatches formed raucous family groups of up to 8 birds each and foraged in the dense thickets or in the canopy of the pines. The Pine Siskins continues to utilize the uppermost branches of the tallest trees and were not seen on the ground as they were on the other sites.

The burn site, Wild Bill 1973, showed a similar change in numbers of breeding pairs per 40 hectares between the two seasons though not so dramatic as on the Pearson Natural Area. In 1975 the area supported 13 species with 119 pairs per 40 hectares (Table 12). In 1976 there were 14 species with 166 pairs per 40 hectares (Table 13). Two large species were gained in 1976, the Robin and the Sparrow Hawk. One medium sized species, the Mountain Bluebird, was lost. The latter started to nest in the area, after claiming the same territory it had used the previous season, but was chased off by the more aggressive Western Bluebird. All breeding species either doubled their numbers or remained at the same density. Excpetions were the Chipping Sparrow and the Lark Sparrow which, while not quite doubling their numbers,

did show a substantial increase, and the Common Nighthawk whose density in 1976 was half that of 1975. This latter reduction may have occurred because the Nighthawk prefers to nest on bare ground and the percent ground cover was quite high by the time the birds arrived to breed in June, 1976 (Table 2).

Standing crop biomass, consuming biomass and existance energy in 1976 all showed an increase corresponding to the increase in birds (Tables 12 and 13).

J' decreased from .92785 in 1975 to .88380 in 1976 in 1976 (Table 10). Although the decrease is probably not significant, it does indicate a slightly greater representation by the members of some species than others in 1976.

Early in the breeding season in 1976 a large number of Yellow-rumped Warblers were observed foraging on the ground with the Chipping and Lark Sparrows. These soon left as breeding progressed, presumably to nest in the unburned portion of the forest. Lowe et al (in press) also notices this and counted them in his sample. However, as they did not nest on the site, they were not counted as breeding birds in the bu n area in the current study. In late July 1975 and 1976, the area enjoyed an influx of migrants that foraged mostly on the ground in small mixed flocks. American Goldfinches, Lesser Goldfinches, House Finches, Pine Siskins and Yellow-rumped Warblers all formed a part of these groups. A large flock of Pinon Jays was occasionally seen in the area though they did not nest there. Also in late July, 1976, a pair of Western Kingbirds and a pair of Rufous-sided Towhees visited the area. Because of the lateness of these arrivals, the birds were considered transients or migrants and not included in the census of breeding birds. Pine Siskins were seen on the ground in the burn area after fledging young whereas they remained in the canopy stratum in the Pearson Natural Area.

In both 1975 and 1976 Hairy Woodpeckers were observed feeding later in the breeding season. They tended to form small groups of from 4 to 6 birds.

The study site on the Rattlesnake Burn showed a more spectacular change in

richness and abundance between the two years than on any other site. The number of species went from 9 in 1975 to 14 in 1976 and number of pairs per 40 hectares more than doubled, from 76 to 180 (Tables 14 and 15). This could have been due in part to the increased moisture in the spring of 1976. It could also have been due to the fact that censusing was started quite late in 1975 (the first census was 21 June) and only 5 censuses were completed. Since 10 censuses are recommended for an accurate estimation of population numbers (Enemar, 1959) the survey may have been an underestimation. However, five of the additional species in 1976 were seen and heard throughout the spring and summer. These five were the Pygmy Nuthatch, Broad-tailed Hummingbird, Brown-headed Cowbird, Northern Three-toes Woodpecker and Acorn Woodpecker. Only those seen in the early part of the 1976 season were likely to have been missed if they were present in 1975. These were the Robin and the Mourning Dove. The above adds credence to the supposition that at least 5 of the additional species in 1976 were not seen in 1975 because they did not nest on the site.

Two species, the Brown-headed Cowbird and the White-breasted Nuthatch, did not nest on the Rattle Burn in 1976 but did so in 1975. However, four white-breasted Nuthatches were observed feeding on the site, apparently together in late July, 1976. Therefore, though these birds did not nest on the site, they did move into the area after the young had fledged.

Of the 7 species gained in the second year, all but two, the Pygmy Nuthatch and the Broad-tailed Hummingbird, were larger bodied birds. The sizes ranged from 30.8 gms. for the female Brown-headed Cowbird to 135 gms. for the Mourning Dove. Of the two smaller species, only the Pygmy Nuthatch was never observed feeding on the site. Although the nest was near the center of the burn, both adults made foraging flights into the adjacent unburned forest when the nest contained young.

All species (except two) nesting in both years at least doubled their numbers in 1976 over those counted in 1975 (Tables 14 and 15). The Hairy Woodpecker could

have been inhibited somewhat by the presence of the other Picidae, especially the Northern Three-toed Woodpecker.

Standing crop biomass, consuming biomass and existance energy showed and increase proportionate to the increase in birds (Tables 14 and 15).

J' remain much the same for the two years: .8575 and .8502 respectively (Table 10). This indicates that the proportion between observed and expected evenness remained the same in spite of the dramatic change in densities.

In late July through early August, 1976, small flocks and family groups of birds were observed feeding in the area. Gray-headed Juncos and Pine Siskins in several flocks of from 8 to 20 birds were seen ranging over the area. Robins, Western Bluebirds and White-breasted Nuthatches formed family groups and flow rapidly back and forth through the area or fed briefly on the ground in the early morning. The Hairy Woodpecker was also seen in a group of three birds or in a pair. In both years, the Common Flicker was often seen in groups of four to six birds later in the season.

Wild Bill 1976 burn site had relative paucity of bird life. Although there was no change in the number of species nesting on the area between the two years (7 in 1975 and 1976, Tables 16 and 17), number of pairs per 40 hectares nearly doubled from 37 to 68. Increases were evident for medium sized birds, such as the Gray-headed Junco, Western Bluebird and Green-tailed Towhee. The Rock Wren, which nested both on the study site and in burned areas surrounding the site in 1975 was not seen or heard in 1976. The reason for its abandoning the area is unknown. This species does require barren ground for nest sites but the percent bare ground in Wild Bill 1967 was approximately the same in both years (40.1% and 40.0% to 46.5% in 1975 and 1976 respectively, Tables 2 and 3). It is possible that the presence of the nesting Sparrow Hawk depressed nesting activity by all smaller birds. This remains to be proven:

The three species that showed an increase in abundance were all ground fencing birds. Their greater numbers could be attributed to the wetter spring and an increase in available foods in 1976. In 1976 Pygmy Nuthatches were observed nesting in a snag in the burned area but outside of the study plot. As was observed with the nesting pair on the Rattle Burn, however, the birds were seen to forage exclusively in the adjacent unburned or lightly burned forest.

As on the other sites, standing crop biomass, consuming biomass and existance energy requirements showed an increase corresponding to the increase in numbers of birds present on the site.

J' showed the greatest change compared to all the other sites being reduced from .9322 in 1975 to .8273 in 1976 (Table 10). This skewedness could be the result of the large number of nesting Greentailed Towhees in 1976 in relation to the other birds. Almost one third of the total nesting species in 1976 were Green-tailed Towhees.

Towards the end of the season, the Western Bluebirds formed small family groups and continued to forage in the area. Robins, also in small groups usually of three to four birds, were also observed foraging in the area in late July. In the very early season (May) and in the late season (August), 1976, Yellow-rumped Warblers were observed feeding on the ground in tiny flocks as on Wild Bill 1973.

DISCUSSION

There were four species common to all sites in 1975 and five in 1976 (Table 18). These were the Gray-headed Junco, Common Flicker, Western Bluebird and Hairy Woodpecker. The fifth species in 1976 was the Broad-tailed Hummingbird. Three of these general species were ground feeders and four were either ground or cavity nesters. Thus a heavy foliage cover was not required for successful nesting by these birds. Wild Bill 1973 and the Rattle Burn both contained trees that retained enough dead foliage to provide ample protection for nesting Broad-tailed Hummingbirds. On all sites Broad-tailed Hummingbirds were seen feeding on composite flowers (notably, *Cirsium* sp.).

Each site contained unique species in both 1975 and 1976 (Table 18). There were no birds common to the burn sites that were not also found in the Pearson Natural Area. One possible exception was the Sparrow Hawk. A pair was found nesting near the boundary of the Rattle Burn site in 1976. However the pair was excluded from the Rattle Burn census because although it foraged in the burn, it was not seen to enter the burn study plot during the season. Also, the nest was located in a snag in an unburned portion of the forest.

The index of community similarity shows the areas to be somewhat similar though not impressively so (Table 19). The slightly higher indices in 1976 show that the sites held more species in common between them than in 1975. It is possible that the more temperate spring of 1976 made the burn sites more attractive in general, allowing more birds to nest than in 1975.

The number of breeding birds observed feeding on the ground increased over the season on all sites (figure 2). The Pearson Natural Area and Wild Bill 1973, however, show only a slight increase; the Rattle Burn site and Wild Bill 1967 show a much more dramatic change. Although none of the curves are significant ($P < 2.920$) this could be more a factor of small sample size ($n=4$) than an indication that the trend is not occurring.

It is interesting to speculate on why the breeding bird populations on the Pearson Natural Area and on Wild Bill 1973 show the same trends in 1976 (figure 2). The sites do not show a great deal of similarity (C_λ=.4865, Table 19). These 11 species constituted 78.5 percent of the population of Wild Bill 1973 but only 47.8 percent of the population on the Pearson Natural Area. Of the 1976 breeding bird populations on Wild Bill 1973 72.7 percent were ground feeders. This was 72.9 percent of the total population (Table 13). On the Pearson Natural Area, 30.4 percent of the species and 30.2 percent of the total population were ground feeders (Table 9). Wild Bill 1973 showed a high number of birds observed on the ground per hour initially because of the presence of foraging Yellow-rumped Warblers. Since most of the breeding species on the area were ground feeders, the numbers per hour remain relatively constant throughout the season. On Wild Bill 1973 the anticipated increase of birds after fledging did not occur but there were large numbers of migrants in the area in late July and early August which were not counted in the sample. Thus the regression slope is small (m=.5). It is possible that the presence of these migrants influence use of the area by the breeding birds.

On the Pearson Natural Area, the increase in birds after fleding did not occur as was hypothesized. Thus the regression slope is also very small (m=.45). However, the area also did not support a large number of migrants late in the season. Therefore, although superficially and in observing figure 2, the two populations seem to be acting in the same or a similar way, in actuality, because of the different natures of the two populations, they are acting quite differently. The regression slope for Wild Bill 1973 would probably be much steeper and more similar to those computed for the Rattle Burn and Wild Bill 1967, had the migrants been included in the sample.

The Spearman Bank Correlation Coefficient showed no significance at the .05 level when comparing the number of ground feeders observed per hour to any measured components of the vegetation ($P<1.00$ at 0.05). The r_s for percent ground cover and

the proportion of ground feeding birds in the sample came closest to significance, however (.6 and .7 for 1975 and 1976 respectively). Again, this lack of significance could be a difficulty of the small sample size rather than an indication that the trend is not occurring.

The percent change in breeding bird density between the two years show the Pearson Natural Area and Wild Bill 1973 populations to be responding similarly (29.09% and 28.31 % change on the two respective sites, Table XX). Both the Rattle Burn and Wild Bill 1967 show rather dramatic differences in density between the two study years (57.78% and 45.59% respectively). These figures indicate that the bird populations on the latter two burn sites are less well buffered against environmental changes. The areas could be suboptimum for the breeding birds involved. The increase in density in 1976 could be an indication that the 1975 season was a good breeding year, many young surviving to fill the optimum breeding areas and flood the suboptimum ones in 1976. It could also indicate that 1976 was a potentially good breeding year and the wet, temperate spring made the suboptimum burn areas more attractive to breeding birds. However, it must be noted that the density changes on Wild Bill 1967 involved shifts in abundances while those on the Rattle Burn resulted from changes in richness.

The above argument infers that the Pearson Natural Area and the burn site, Wild Bill 1973, are relatively well buffered against environmental fluctuations or that they are optimum areas for the breeding species. Wild Bill 1973 population fluctuations could be dampened somewhat by the presence of the Chipping and Lark Sparrows which prefer grassy and brushy areas in which to nest. If those two species had increased their numbers in 1976 in keeping with the trend shown by most of the other breeding species on the site (ie, doubled their numbers), percent change between the two years would be over 40%. This figure is more within the range calculated for the other two burn sites.

The expected increase in abundance and richness of the breeding bird populations nesting in burned ponderosa pine forests around Flagstaff, Arizona, did not

occur. Contrary to what other workers have found in other forests, there was a dramatic decrease in numbers of species, number of individuals, and standing crop and consuminb biomass between burned and unburned forests.

Johnson and Odum (1956) hypothesize that a community will increase in species diversity through its successional stages. At climax, this diversity is reduced possibly because of the achievement of a vegetational monoculture, possibly because of a reduction in understory strata. Other studies have shown this successional increase in diversity mostly by comparing the avifauna in disturbed sites to so-called climax communities (Karr, 1968; Hagar, 1960).

The general assumption is that a climax community is one which reproduces its own kind and is free from disturbance. Any environmental destruction, such as flood or fire, is considered a detriment to a community and to set back development and production to a younger successional stage. If this is the case, one should expect an increase in the associated fauna after disturbance. However, there are some communities that are disaster dependent, that is, a disturbance of some kind which results in the clearing of existing vegetation is required for reproduction of the climax vegetation to occur. In this second case, the disturbance acts to maintain community maturity and one should expect a corresponding decrease in faunal diversity after disturbance.

Fire in the ponderosa pine forest acts to maintain the integrity of the community as a monoculture. The Kaibab National Forest on the North Rim of the Grand Canyon, Arizona, is, essentially, a mixed forest composed of tall, mature ponderosa pine and an understory of spruce (Picea engelmanii Perry), White Fir (Abies concolor (Gordon & Glendinning) Lindl.), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco.) and Aspin (Populus tremuloides Michx.). After control burning on a 72 acre site, the understory was completely destroyed, leaving only the tall pines (Ruffner et al., unpubl.). Vegetational diversity had been effectively reduced and the forest climax

condition -- a ponderosa pine monoculture -- achieved. Associated with this was a reduction in the avifaunal component of the habitat (Ibid).

In the current study, fire again burned out the understory layer which, in Flagstaff area, is composed of small pines. Many of the birds missing in the burn site were foliage gleaning birds such as Grace's Warbler, Mountain Chickadee, Solitary Vireo, Steller's Jay and Pygmy Nuthatches. Because the fire also burned into the canopy, many birds using the upper stratum were also lost, such as Yellow-rumped Warbler, Pine Siskin, and Robin.

Because of the reduction in foliage the burn areas also lacked protection in the form of cover. This could make the areas suboptimum for those birds requiring protection against predators during nesting. However, burning tends to stimulate germination and growth of forage grasses (Cooper, 1960). This lush growth can, in turn, increase the attractiveness of the area to ground nesting and feeding birds.

One should expect after a fire in a ponderosa pine community, a decrease in avifaunal diversity as well as a shift in species composition from predominately canopy and shrub inhabiting birds to canopy and ground inhabiting species. That the three burn areas were only barely similar to the control shows that these changes are occurring. The majority of the birds common between the Pearson Natural Area and the three burn sites were ground foragers and/or nesters. In all cases the number of birds observed on the ground increase as the season progressed. Although the increase was not statistically significant, the trend is apparent. An increase in the proportion of ground users with increase in ground cover was also occurring, although, again not significant. This point needs further investigation and, it is felt that factors in addition to ground cover were influencing the presence of ground birds.

The Pearson Natural Area contained 23 breeding species. The Pearson Natural Area plus the three burn sites supported a minimum of 33 nesting species over a two year period plus an additional 8 species which were transients or migrants. This is an important point for forest managers to keep in mind.

The only way to attain habitat diversity in these forests is to vary the age of the stands and the density of the trees locally (Cooper, 1968). Shrubby thickets prove very attractive to some species such as Mountain Chickadees, Solitary Vireos and Pygmy Nuthatches but are very disadvantageous in the face of a fire. Open areas, such as Wild Bill 1967, support unique species such as the Green-tailed Towhee but such areas are very nonproductive from a foresters point of view. Semi-open areas such as Wild Bill 1973 and the Rattle Burn site, support a larger number of flycatchers and ground feeders than are found in the unburned pine forest but some diversity is lost due to the absence of foliage gleaners and canopy nesters.

The most effective manner of increasing bird species diversity in an area is to increase the heterogenetiy of the habitat. In a pyroclimatic monoculture this is best achieved by maintaining patches of divergent types of habitat structure. Fire is one method of maintaining these patches and, in the long run, could be the most economical. Differential burning within a single blaze may create patches. Fires may jump, leaving small, semi-isolated areas to thicket; they may burn hot in some sections, creating a meadow-like opening such as in Wild Bill 1967. They may burn moderately, acting to clear out accumulated fuels, duff and litter and thickets. In all cases, fire seems to act as a stimulant to forage and pines, instigating a new cycle of growth.

References

Bendell, J.F. 1974. Affects of fire on birds and mammals. IN: T.T. Kozlowski (ed.). Fire and Ecosystems. Academic Press. New Yor,. 542 pp.

Bock. C.E. and J.F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forests in the Sierra Nevada. The Condor, 72:182-189.

Carothers, S.W., R.R. Johnson and S.W. Aitchison. 1974. Population structure and social organization of southwestern riparian birds. Amer. Zool., 19:97-108.

Cooper. C.F. 1960. Southwestern pine forests since white settlement. Ecol. Monog., 30:129-164.

Cooper, C.F. 1964. Pattern in ponderosa pine forests. Ecol., 42:493-499.

Cox, G.W. 1972. Laboratory Manual of General Ecology. Wm. C. Brown Company Publishers. 195 pp.

Enemar, A. 1959. On the determination of the size and composition of a passerine bird population during breeding season. Var. Fagelwarld. Supplement 2.

Habeck, J.R. and R.W. Mutch. 1973. Fire-dependent forests in the northern Rocky Mountains. Quaternary Research, 3:408-424.

Hagar, D.C. 1960. The interrelationships of logging, birds, and timber regeneration in the Douglas-Fir region of northwestern California. Ecol., 41:116-125.

Haldeman, J.R., R.P. Balda and S.W. Carothers. 1973. Breeding birds of a Ponderosa Pine forest and a Fir, Pine, Aspin forest in the San Francisco Mountains area, Arizona. Museum of Northern Arizona Tech. Series No. 12.

Halvorson, W.L. 1972. Environmental influence on the pattern of plant communities along the North Rim of Grand Canyon. Amer. Midland Naturalist, 97:222-235.

James, F.C. and H.H. Shugant, Jr. 1970. A quantitative method of habitat descript-ion. Audubon Field Notes, 24:727-736.

Johnson, D.W. and E.D. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecol., 37:50-62.

Kallander, P.S. 1969. Controlled burning on the Fort Apache Indian Reservation, Arizona. Tall Timbers Fire Ecol. Conf. Proceed., No 9:241-250.

Karr, J.R. 1968. Habitat and avian diversity on strip mined land in east central Illinois. The Condor, 70:348-357.

Kendeigh, S.C. 1944. Measurement of bird populations. Ecol. Monog., 14:67-106.

Kilgore, B.M. 1971. Response of breeding bird populations to habitat changes in a giant sequoia forest. Amer. Midland Naturalist, 85:135-152.

Li, J.C.R. 1969. Statistical Inference: Vol. 1. Edwards Brothers, Inc. 658 pp.

Lowe, P.O., P.F. Ffolliott, J.H. Dieterich and D.R. Patton. 1976. Potential wildlife benefits of fire in Arizona Ponderosa Pine forests. In press.

MacArthur, R.H. 1964. Environmental factors affecting bird speices diversity. Am. Nat. 98:387-397.

Marshall, Jr., J.T. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna, no. 32.

Martin, N.D. 1960. An analysis of bird populations in relation to forest succession in Algonquin Provincial Park. Ontario. Ecol., 41:126-140.

Mayfield, H.F. 1960. The Kirklands Warbler: Bloomfield Hills, Michigan. Cranbrook Inst., Sci. Bull. No. 40, p 242.

McDougall, W.B. 1973. Seed Plants of Northern Arizona. Museum of Northern Arizona. 594 pp.

Merriam, C.H. 1980. Results of a biological survey of the San Francisco Mountain Region and the desert of the Little Colorado River, Arizona. North American Fauna, 3:136 pp.

Miller, A.H. 1955. The avifauna of the Sierra del Carmen of Coahuila, Mexico. The Condor. 57:154-178.

Morisita, M. 1959. Measuring of interspecific association and similarity between communities. Mem. Fac. Sci. Kyushu Univ. Sev. E., 3:65-80.

Nelson, J.R. 1974. Forest fire and big game in the Pacific Northwest. Tall Timbers Fire Ecol. Conference Proceed., No. 15:85-102.

Odum, E.D. 1950. Bird populations of the highlands (North Carolina) plateau in relation to planet succession and avian invasion. Ecol., 31:587-605.

Pearson, H.A., J.R. Davis and G.H. Schubert. 1972. Effects of wildfire on timber and forage production in Arizona. Jour. of Range Management, 25:250-253.

Pileon, E.C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. Jour. Theoretical Biol., 10:370-383.

Poole, E.L. 1938. Weights and wing areas in North American birds. Auk. 55:511-517.

Rietveld, W.J. 1975. Phytotoxic grass residues reduce germination and initial root growth of ponderosa pine. U.S.D.A. Forest Service Research Paper RM-153, 15 pp.

Roppe, J.A. 1975. Effects on wildlife of a fire in a lodgepole pine forest. MS. Colorado State Univ.

Ruffner, G.A., S.W. Carothers and J.H. Overturf. 1976. North Rim fire ecology studies. U.S.D.I. unpublished manu.

Salt, G.W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. The Condor, 59:373-393.

Shannon, C.D. and W. Weaver. 1949. The Mathematical Theory of Communication. Urbana, Ill. Univ. of Illinois Press. 117 pp.

Siegel, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Co., 312 pp.

Skarra, P.E. 1969. Some observations on Indian forests and prescribed burning. Tall Timbers Fire Ecol. Conference Proceed., No 9:209-212.

Strahler, A.N. 1969. Physical Geography. John Wiley and Sons, Inc., 733 pp.

Sweeney, J.R. 1956. Responses of vegetation to fire. Univ. of California Publ., Bot., 28:143-250.

Weiner, J. and Z. Glowacinski. 1975. Energy flow through a bird community in a deciduous forest in southern Poland. The Condor, 77:233-242.

Wiens, J.A. 1975. Avian communities, energetics, and functions in coniferous forest habitats. Proceed. on the Symp. on Management of Forest and Range Habitats for Non-game Birds. May 6-9:226-265.

Williams, A.B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monog., 6:317-408.

Winkworth, R.E. and D.W. Goodall. 1962. A crosswire tube for point quadrat analysis. Ecol., 43:342.

Table 1

Area	Absolute density, trees/Ha Ponderosa Pine	Saplings/Ha	Importance value of P. pine	Absolute density burned stems/Ha	Approximate absolute density pre-burn
son Nat'l Area	588	20,105	295	0	588
Bill, 1973	38	83	65.6	505	610
le Burn	8	43	-	390	500
Bill, 1967	30	0	93	58	190

Table 2
Percent Cover

Area	Ground vegetation	Ground fuels	Open ground	Sapling cover	Canopy cover
son Nat'l Area	27.8	4.7	66.6	33.0	50.5
Bill, 1973	46.9	4.5	48.6	0	0
e Burn	49.1	11.4	39.8	0	0
Bill, 1967	35.5	24.1	40.1	0	0

Table 3
Percent cover by collection period, 1976
V=vegetation F=fuels B=open ground

ollec-ion eriod	Pearson Nat'l Area			Wild Bill, 1973			Rattle Burn			Wild Bill, 1967		
	V	F	B	V	F	B	V	F	B	V	F	B
y	18.125	3.125	69.375	40.312	3.438	56.563	33.125	15.625	50.938	29.063	14.063	56.250
une	20.938	1.563	70.313	46.880	5.620	47.500	45.937	14.375	40.936	41.250	19.063	40.000
ıly	27.500	4.375	68.125	54.688	9.375	35.938	47.188	14.375	38.438	31.563	22.188	44.688
ıgust	29.063	2.188	68.750	63.750	3.750	32.500	52.813	15.313	31.875	36.563	18.438	46.563

Table 4

List of Plants collected from the Pearson Natural Area, 1975-76.

Blepharoneuron tricholepsis (torr.) Nash.

Poa fendleriana (Steud.) Vasey

Sittanion Longifolium J.G. Smith

Chenopodium berlandieri Moq.

Furotia Lanata (Pursh) Moq.

Thalictrum fendleri Engelm.

Fragaria ovalis (Lehm.) Rydb.

Potentilla crinita Gray.

Lotus wrightii (Gray) Greene

Lupinus argenteus Pursh.

Oxytropis Lambertii Pursh.

Petalostemon candidum (Willd.) Michx.

Vicia americana Muhl.

Geranium caespitosum James

Euphorbia Lurida Engelm.

Ceanothus fendleri Gray.

Pseudocymopterus montanus (Gray.) Coult. & Rose

Gilia aggregata (Pursh) Spreng.

Cryptantha setosissima (Gray) Payson

Lithospermum multiflorum Torr.

Castilleja integra Gray

Renstemon virgatus Gray

Houstonia wrightii Gray

Achillea Lanulosa Nutt.

Antennaria parvifolia Nutt.

Table 4 continued

Antennaria rosulata Rydb.

Cirsium vulgare (Savi) tenore

Erigeron flagellaris Gray.

Hymenopappus Lugens Greene.

Senecio multilobatus Torr. & Gray

Towsendia excapa (Richards) Porter

Table 5
List of Plants Collected from Wild Bill 1973 Study Area, 1975-76

Agropyron desertorum (Fisch.) Schult.

Blepharoneuron Tricholepsis (Torr.) Nash.

Boutelour gracilis (H.B.K.) Lag.

Bromus inermis Leyss

Dactylis glomerata L.

Hordeum jubatum L.

Lolium perenne L.

Phleum pratense L.

Poa fendleriana (Steud.) Vasey

Eriogonum nacemosum Nutt.

Rumex crispus L.

Chenopodium berlandieri Moq.

Salsola kali var. Tenuifolia Tausch.

Corydalis aurea Willd.

Arabis fendleri (Wats.) Greene

Eyrsimum capitatum (Doug L.) Greene

Sisymbrium Linearifolium (Gray) Payson

Lotus wrightii (Gray) Greene

Lupinus kingii Wats.

Melilotus officianlis (L.) Lam.

Oxytropis Lambertii Pursh.

Geranium Caespitosum James

Linum aristatum Engelm.

Linum Lewisii Pursh.

Euphorbia Lurida Engelm.

Table 5 continued

Sphaeralcea fendleri Gray

Gauna coccinea (Nutt.) Pursh.

Oenothera caespitosa Nutt.

Gilia aggregata (Pursh) Spreng.

Gilia multiflora Nutt.

Cryptantha jamesii (Torr.) Payson

Cryptantha setosissima (Gray) Payson

Castilleja integra Gray.

Penstemon virgatus Gray.

Verbascum thapsus L.

Aster arenosus (Heller) Blake.

Cirsium vulgare (Savi) Tenore

Erigeron flagellaris Gray

Helianthus petiolaris Nutt.

Hymenopappus Lugens Greene

Lactuca seriola L.

Senecio Longilobus Torr. & Gray

Stephanomeria thruberi Gray

Taraxacum officinale Weber.

Tragopogon dubius scop.

Table 6
List of Plants Collected From the Rattle Burn, 1975-76

Agropyron intermedium

Agrostis alba L.

Andropogon scoparius Michx var. frequens Hubb.

Blepharoneuron Tricholepsis (Torr.) Nash

Bromus japonicus Thunb.

Dactylis glomerata L.

Festuca arizonica Vasey

Festlica ovina L.

Phleum pratense L.

Poa fendleriana (Steud.) Vasey

Poa pratense L.

Sitanion Longifolium J.G. Smith

Carex sp.

Triteleia Lemmonae (Wats.) Greene

Quercus gambellii Nutt.

Rumex crispus L.

Chenopodium berlandieri Moq.

Draba aspnella Greene

Lepidium medium Greene

Fragaria ovalis (Lehm.) Rydb.

Rosa arizonica Rydb.

Lotus utahensis Ottley.

Lotus wrightii (Gray) Greene)

Lupinus palmeri Wats.

Melilotus officianlis (L.) Lam.

Robinia neomexicana Gray

Vicia americana Muhl.

Euphorbia Lurida Engelm.

Ceanothus fendleri Gray

Epilobium paniculatum Nutt.

Gayophytum nuttallii T. & g.

Oenothera Laciniata Hill. var. pubescens (Willd.) Munz.

Pseudocynopterus montanus (Gray) Coult. & Rose

Apocynum androsaemifolium L.

Convolvulus arvensis L.

Linanthastrum nuttallii (Gray) Ewan.

Verbena bracteata Lag. & Rodr.

Monarda menthaefolia Graham.

Castilleja integra Gray

Penstemon virgatus Gray

Verbascum thapsus L.

Veronica peregrina L. ssp. xalapensis (H.B.K.) Pennell.

Houstonia wrightii Gray

Achillea Lanulosa Nutt.

Antennaria parvifolia Nutt.

Antennaria rosulata Rydb.

Circium vulgare (Savi) Tenore

Conyza canadensis (L.) Cronquist.

Hymenoxys richardsonii (Hook.) Cockerell.

Layla glandulosa (Hook.) Hook. & Arn.

Senecio actinella Greene

Senecio multilobatus Torr. & Gray.

Table 6 continued

Senecio wootonii Greene

Taraxacum officinale Weber.

Tragopogon dubius Scop.

Table 7
List of Plants Collected From Wild Bill 1967 Study Area, 1975-76

Bromus inermis Leyss.

Bromus tectorum L.

Dactylis glomerata L.

Festuca ovina L.

Phleum pratense L.

Carex sp.

Corydaus aurea Willd.

Sanguisorba minor

Lathyrus arizonicus Britton.

Lupinus argenteus Pursh.

Euphorbia Lurida Engelm.

Ceanothus fendleri Gray

Oenothera Laciniata Hill. var. pubescens (Willd.) Munz.

Lithospermum multiflorum Torr.

Verbascum thapsus L.

Houstonia wrightii Gray

Antennaria parvifolia Nutt.

Antennaria rosulata Rydb.

Cirsium vulgare (Savi) Tenore

Erigeron flagellaris Gray.

Hymenoxys bigelovii (Gray) Parker

Senecio multilobatus Torr. & Gray

Table 8

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Pearson Natural Area-1975

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec)
iolet-green Swallow	40	10.6	Salt[1]	763.2	356.8	772.81
ygmy Nuthatch	32	10.1	MNA[2]	646.4	276.48	602.06
ray-headed Junco	30	20.3	MNA	609.0	403.2	829.24
estern Bluebird	23	24.5	MNA	980.0	348.22	705.33
ountain Chickadee	22	12.0	Salt	528.0	212.08	455.13
rowndreeper	17	8.0	Salt	160.0	126.82	282.48
estern Wood Peewee	13	12.01	MNA	312.3	125.32	268.94
hite-breasted Nuthatch	10	20.4	Salt	205.6	135.00	276.73
ellow Rumped Warbler	10	11.4	MNA	228.0	93.4	201.19
ourning Dove	7	135.0	Salt	1890.0	312.34	563.46
airy Woodpecker	7	69.8	Salt	977.2	205.66	386.45
rown-headed Cowbird	7	37.7	MNA	263.9	69.65	133.27
	7	30.8	MNA	215.6	61.25	121.84
obin	7	84.8	MNA	1229.2	237.86	440.34
olitary Vireo	7	16.6	Salt	232.4	82.88	172.97
race's Warbler	7	7.5	Salt	105.0	50.12	112.17
teller's Jay	6	105.6	MNA	1267.2	229.2	419.51
estern Tanager	3	29.4	MNA	176.4	51.0	101.73
ommon Flicker	3	145.0	MNA	870.0	140.04	251.63
Totals	251			11739.4	3517.32	7097.28

[1] Salt, 1957

[2] Museum of Northern Arizona

Table 9

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Pearson Natural Area-1976

Species	No Pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec)
gmy Nuthatch	53	10.1	MNA[1]	1070.6	457.92	1011.52
olet-green Swallow	50	10.6	Salt[2]	1060.0	446.0	979.79
ne Siskin	37	12.0	MNA	648.0	356.68	776.12
ay-headed Junco	33	20.3	MNA	1339.8	443.52	923.69
stern Bluebird	30	24.5	MNA	1470.0	454.2	931.21
untain Chickadee	30	12.0	Salt	720.0	289.2	629.29
bin	17	84.8	MNA	2883.2	577.66	1079.49
ite-breasted Nuthatch	13	20.4	Salt	530.4	175.5	364.29
llow-rumped Warbler	13	11.4	MNA	296.4	121.42	265.24
urning Dove	10	135.0	Salt	2700.0	446.2	811.89
own Creeper	10	8.0	Salt	160.0	74.6	168.66
stern Wood Peewee	10	12.01	MNA	240.2	96.4	209.76
own-headed Cowbird	7	37.7	MNA	263.9	69.65	134.80
	7	30.8	MNA	215.6	61.25	123.26
eller's Jay	7	105.6	MNA	1478.4	267.4	493.86
mmon Flicker	7	145.00	Salt	2030.0	326.76	592.12
ace's Warbler	7	7.55	Salt	105.0	50.12	113.87
litary Vireo	5	16.66	Salt	83.0	59.2	123.55
iry Woodpecker	3	69.88	Salt	418.8	88.14	167.26
thern Three-toed wapker	3	58.55	MNA	351.0	78.84	151.82
oad-tailed Hummingbird	3	4.0	Salt	24.0	14.4	34.96
stern Flycatcher	3	12.87	Miller3	77.22	25.92	57.26

Table 9 continued

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec
:rmit Thrush	3	29.5	Poole[4]	177.0	51.12	103.20
:stern Tanager	*5					
Total	354			18342.52	5032.1	10246.91

. Museum of Northern Arizona

. Salt, 1957

. Miller, 1955

. Poole, 1938

. Nested in area but not on site

Table 10

Average Temperatures on the Four Study Sites, 1975 and 1976

	1975	1976
Pearson	11.36	10.46
WB73	18.16	13.89
RaT	13.42	13.59
WB67	11.48	11.59

Table 11

H', H_{max} and J' of the Four Study Sites, 1975 and 1976

		H'	H_{max}	J'
Pearson	1975	3.79357	4.16992	.90975
	1976	4.09962	4.52356	.90628
WB73	1975	3.43347	3.70044	.92785
	1976	3.36498	3.80735	.8838
RaT	1975	2.71809	3.16993	.85746
	1976	3.23711	3.80735	.85022
WB67	1975	2.61701	2.80735	.93220
	1976	2.32256	2.80735	.8273

Table 12

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Wild Bill 1973 Study Area-1975

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existanc energy (kcal/40he
Lark Sparrow	24	24.0	MNA[1]&NAU[2]	1152.0	358.85	659.79
Chipping Sparrow	20	12.2	Salt[3]	488.0	194.86	373.93
Common Nighthawk	10	47.5	MNA	950.0	230.34	408.31
Western Wood Peewee	10	12.01	MNA	240.2	96.4	185.09
Western Bluebird	10	24.6	Salt	492.0	151.88	278.40
Steller's Jay	10	105.6	MNA	2112.0	381.95	651.26
Hairy Woodpecker	7	69.8	Salt	977.2	205.73	357.55
Common Flicker	5	145.0	Salt	1450.0	140.05	392.50
Western Tanager	5	29.4	MNA	294.0	84.27	154.50
Broad-tailed Hummingbird	5	4.0	Salt	40.0	24.0	49.98
Mountain Bluebird	5	28.3	Salt&MNA	283.0	101.43	151.20
Gray-headed Junco	5	20.3	MNA	203.0	67.24	125.0
Solitary Vireo	3	16.6	Salt	99.6	35.52	66.77
	119			7477.0	2072.32	3854.29

1. Museum of Northern Arizona
2. Northern Arizona University
3. Salt, 1957

Table 13

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Wild Bill 1973 Study Area-1976

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass- (gms/40hec)	Existance energy (kcal/40hec)
ark Sparrow	39	24.0	MNA[1]&NAU[2]	1872.0	583.44	1141.49
hipping Sparrow	29	12.2	Salt[3]	707.6	282.46	582.21
estern Bluebird	20	24.5	Salt	980.0	302.8	592.30
airy Woodpecker	12	69.8	Salt	1675.2	352.56	644.05
teller's Jay	10	105.6	MNA	2112.0	382.0	681.35
road-tailed Hummingbird	10	4.0	Salt	80.0	48.0	109.14
estern Wood Peewee	10	12.01	MNA	240.2	96.4	198.77
ray-headed Junco	10	20.3	MNA	406.0	134.4	266.59
obin	5	87.8	MNA	878.0	169.9	306.19
ommon Flicker	5	145.0	Salt	1450.0	233.4	409.38
estern Tanager	5	29.4	MNA	294.0	85.0	163.95
ommon Nighthawk	5	47.5	MNA	475.0	115.2	215.42
parrow Hawk	3	77.7	MNA	466.2	94.38	171.29
olitary Vireo	3	16.6	Salt	99.6	35.52	118.99
	166			11735.6	2915.46	5601.12

. Museum of Northern Arizona

. Northern Arizona University

. Salt, 1957

Table 14

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the RaT Study Area-1975

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec
House Wren	24	10.5	Salt[1]	504.0	212.64	446.67
Western Bluebird	15	24.5	MNA[2]	735.0	227.1	446.84
Western Wood Peewee	7	12.01	MNA	168.14	67.48	140.08
Hairy Woodpecker	5	69.8	Salt	698.0	146.95	269.63
White-breasted Nuthatch	5	20.4	Salt	204.0	67.45	134.27
Brown Creeper	5	8.0	Salt	80.0	37.30	80.16
Olive-sided Flycatcher	5	31.5	Salt	315.0	88.80	171.51
Common Flicker	5	145.0	Salt	1450.0	233.42	411.04
Gray-headed Junco	5	20.3	MNA	203.0	67.24	134.11
Total	76			4357.14	1148.38	2234.31

1. Salt, 1957

2. Museum of Northern Arizona

Table 15

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the RaT Study Area-1976

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec)
House Wren	54	10.5	Salt[1]	1134.0	478.44	1003.03
Western Bluebird	29	24.5	MNA[2]	1421.0	439.06	862.45
Broad-tailed Hummingbird	15	4.0	Salt	120.0	72.0	164.68
Western Wood Peewee	15	12.01	MNA	360.3	144.6	299.60
Gray-headed Junco	15	20.3	MNA	609.0	201.6	401.63
Robin	10	87.8	MNA	1756.0	339.8	614.36
Common Flicker	10	145.0	Salt	2900.0	466.8	821.14
Mourning Dove	5	135.0	Salt	1350.0	223.1	393.87
Pygmy Nuthatch	5	10.1	Salt	101.0	43.2	90.72
Olive-sided Flycatcher	5	31.5	Salt	315.0	88.8	171.24
Hairy Woodpecker	5	69.8	Salt	698.0	146.9	269.26
Northern Three-toed Wdpker	5	58.5	MNA	585.0	131.4	244.11
Acorn Woodpecker	5	65.75	Miller[3]	657.5	141.5	260.34
Brown-headed Cowbird	2	37.7	MNA	75.4	19.9	36.99
	2	30.8	MNA	61.6	17.5	33.81
Total	180			12143.8	2954.6	5667.23

1. Salt, 1957

2. Museum of Northern Arizona

3. Miller, 1955

Table 16

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Wild Bill 1967 Study Area-1975

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec)
Rock Wren	9	16.0	Miller[1]	288.0	104.11	203.88
Green-tailed Towhee	9	27.6	MNA[2]	496.8	147.02	277.88
Sparrow Hawk	5	77.7	MNA	770.0	157.27	279.72
Western Bluebird	5	24.6	Salt[3]	246.0	75.94	144.27
Gray-headed Junco	5	20.3	MNA	203.0	67.24	129.74
Common Flicker	2	145.0	Salt	580.0	93.37	160.86
Hairy Woodpecker	2	69.8	Salt	279.2	58.78	105.12
Total	37			2870.0	703.73	1301.47

1. Miller, 1955

2. Museum of Northern Arizona

3. Salt, 1957

Table 17

Number of Pairs per 40 Hectares, Standing crop Biomass, consuming Biomass of Birds on the Wild Bill 1967 Study Area-1976

Species	No pairs 40 hectares	WT (gms)	Source	Standing crop biomass (gms/40hec)	Consuming biomass (gms/40hec)	Existance energy (kcal/40hec
Green-tailed Towhee	26	27.6	MNA[1]	1435.2	424.84	849.35
Western Bluebird	14	24.6	Salt[2]	688.8	211.96	427.99
Gray-headed Junco	14	20.3	MNA	568.4	188.16	385.73
Sparrow Hawk	5	77.7	MNA	777.0	157.3	292.74
Broad-tailed Hummingbird	5	4.0	Salt	40.0	24.0	57.04
Common Flicker	2	145.0	Salt	580.0	93.36	157.39
Hairy Woodpecker	2	69.8	Salt	279.2	58.76	110.13
Total	68			4368.6	1158.38	2290.37

1. Museum of Northern Arizona

2. Salt, 1957

Table 18

Breeding Species Present on the Four Study Sites in 1975 and 1976

	Pearson Natural Area		Wild Bill 1973 Study Area		Rattlesnake Barn Study Area		Wild Bill 1967 Study Area	
arrow Hawk	x	.		.		.	x	.
urning Dove								
mmon Nighthawk			x	.				
oad-tailed Hummer		.	x	.		.		.
mmon Flicker	x	.	x	.	x	.	x	.
orn Woodpecker						.		
iry Woodpecker	x	.	x	.	x	.	x	.
rthern Three-toed Woodpecker		.				.		
stern Flycatcher		.						
stern Wood Peewee	x	.	x	.	x	.		
ive-sided Flycatcher					x	.		
olet-green Swallow	x	.						
eller's Jay	x	.	x	.				
untain Chickadee	x	.						
ite-breasted Nuthatch	x	.			x			
gmy Nuthatch	x	.				.		
own Creeper	x	.			x			
use Wren					x	.		
ck Wren							x	
bin	x			.		.		
rmit Thrush		.						
stern Bluebird	x	.	x	.	x	.	x	.

Table 18 continued

	Pearson Natural Area	Wild Bill 1973 Study Area	Rattlesnake Barn Study Area	Wild Bill 1967 Study Area
untain Bluebird		x		
litary Vireo	x .	x .		
llow-rumped Warbler	x .			
ace's Warbler	x .			
own-headed Cowbird	x .			
stern Tanager	x .	x .		
ne Siskin	.			
een-tailed Towhee				x .
rk Sparrow		x .		
ay-headed Junco	x .	x .	x .	x .
ipping .parrow		x .		

Table 19

Cλ Index of Community Similarity

1975

	Wild Bill 1973	Rattle Burn	Wild Bill 1967
Pearson Natural Area	.5161	.5185	.3200
Wild Bill 1973		.4545	.3636
Rattle Burn			.500

1976

	Wild Bill 1973	Rattle Burn	Wild Bill 1967
Pearson Natural Area	.4865	.5405	.6667
Wild Bill 1973		.5000	.5714
Rattle Burn			.4762

Table 20

Percent Differences Between 1975 and 1976
on the Four Study Areas

	Density (pairs/40 hr)
Pearson Natural Area	29.09
Wild Bill 1973	28.31
Rattle Burn	57.78
Wild Bill 1962	45.59

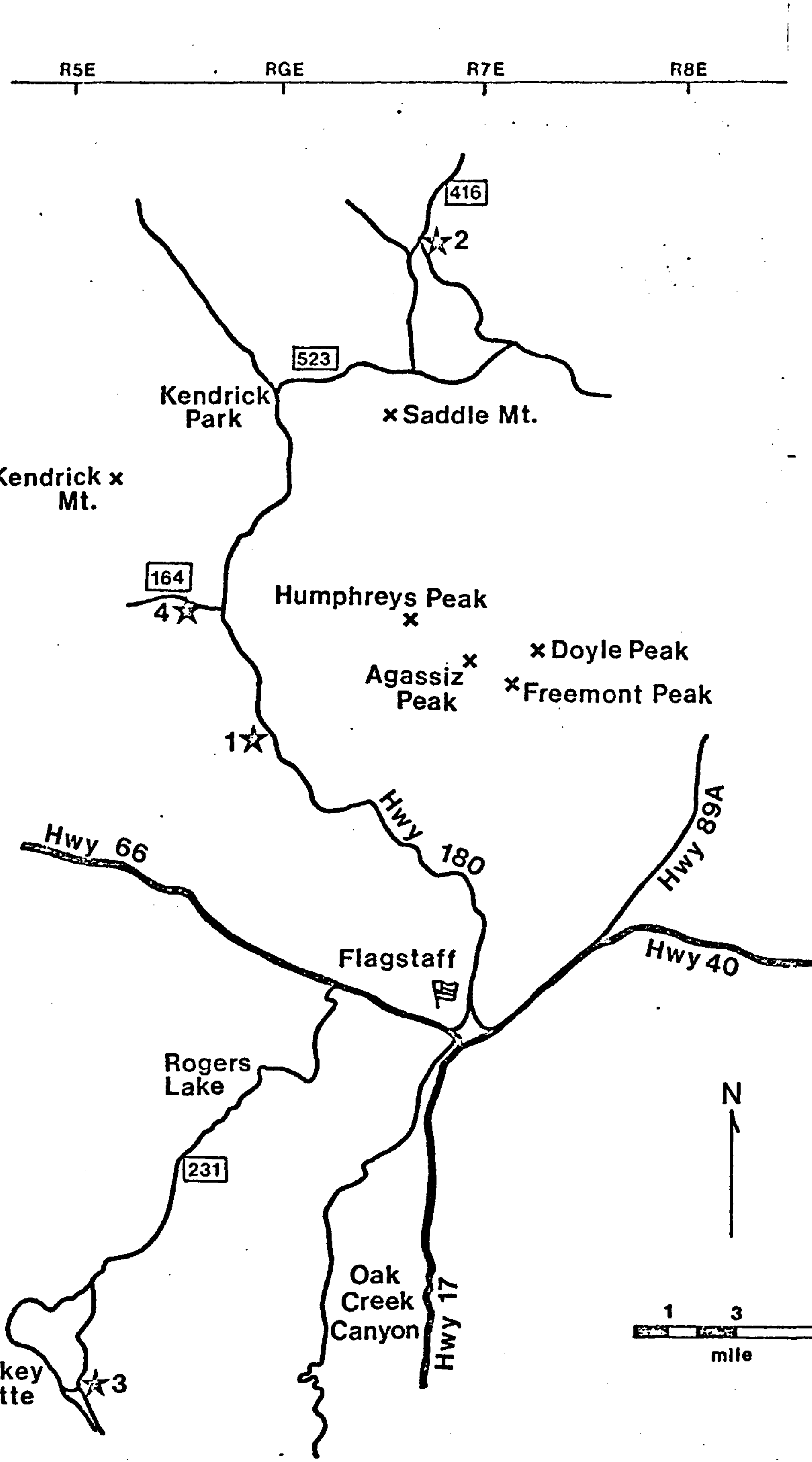
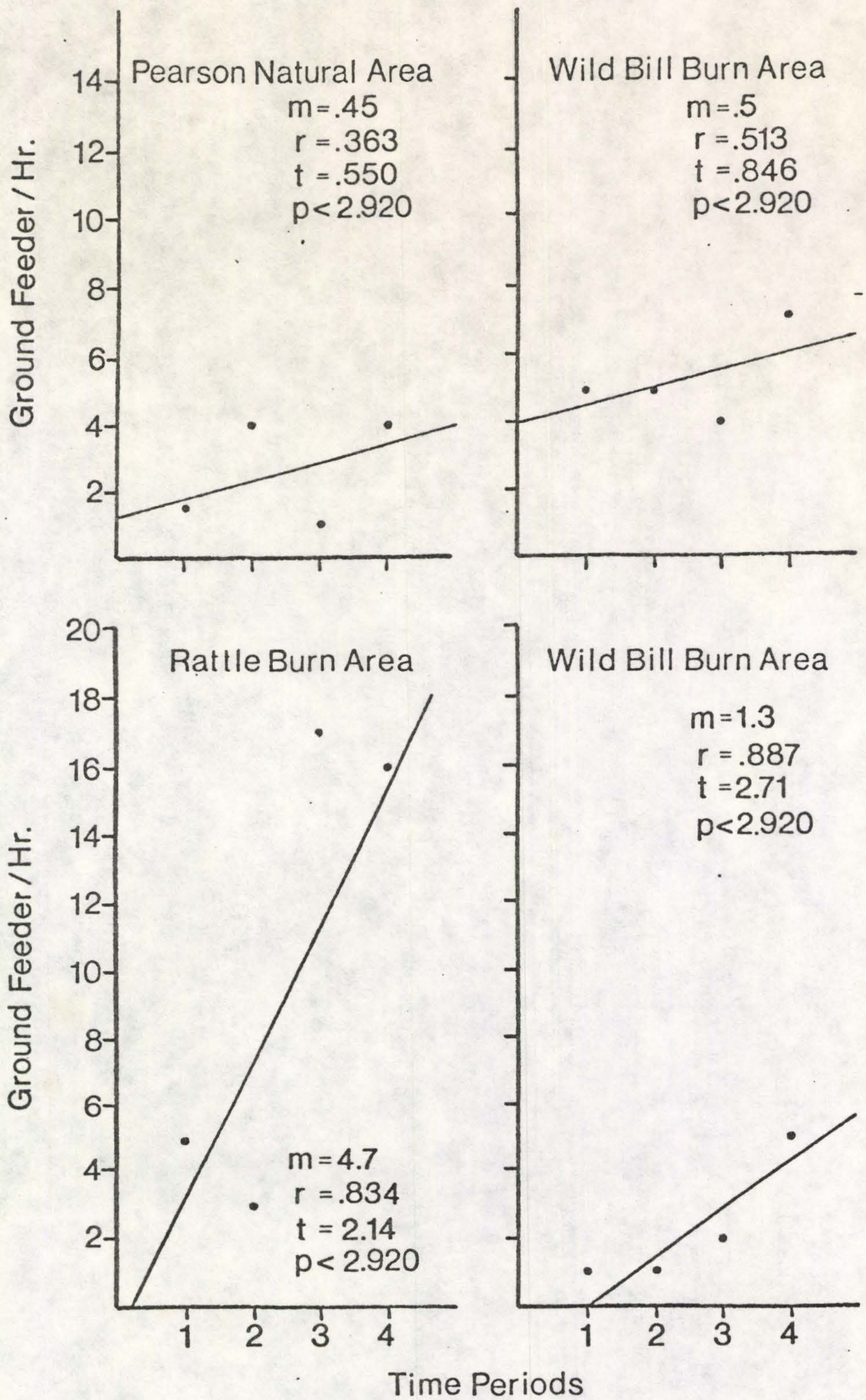


Figure 1.
Location of study sites around Flagstaff, Arizona

Figure 2. Number of ground feeding birds seen per hour during the four study periods on the four study areas.



Pearson Natural Area
m=.45
r =.363
t =.550
p<2.920
Wild Bill Burn Area
m=.5
r =.513
t =.846
p<2.920
Rattle Burn Area
m=4.7
r =.834
t = 2.14
p< 2.920
Wild Bill Burn Area
m=1.3
r =.887
t =2.71
p<2.920
Ground Feeder / Hr.
Ground Feeder / Hr.
Time Periods